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(54) Minimum order UHF TV coupled-cavities broadcasting filter

(57) UHF TV broadcasting band pass filter featuring four cylindrical square-cavity resonators with generalized couplings and Cascade Quadruplet configuration with a sign reversal between the middle resonators, the filter end sections being coupled to the input and output connectors by means of adjustable rotating probes.

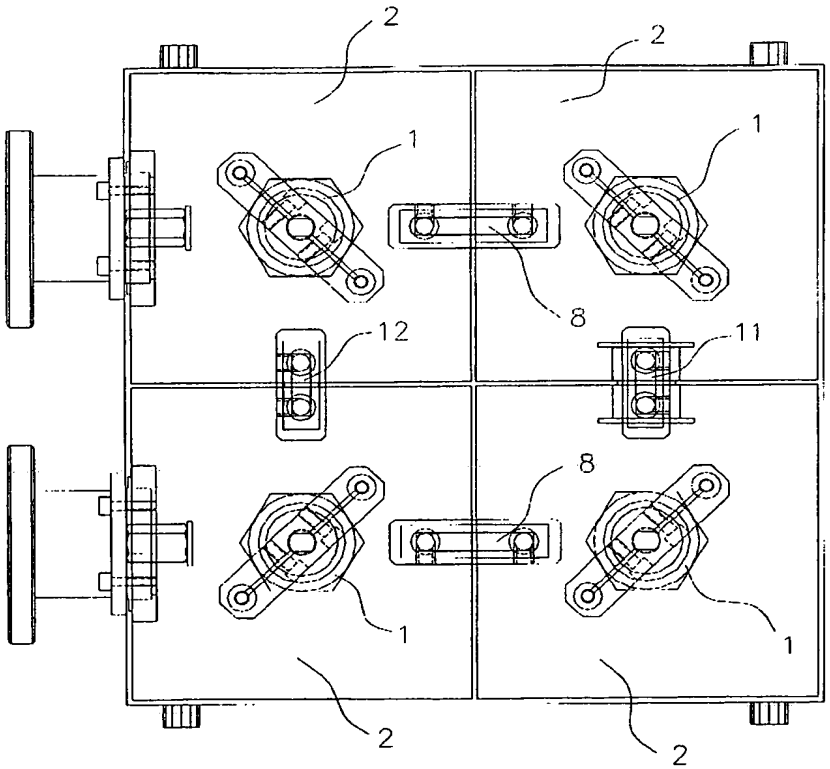

Fig. 1

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D s ription

[0001] This invention is a passive radio frequency (RF) filter with coupled cavities specifically conceived for UHF TV broadcasting.

[0002] As is known, high-frequency low-loss filters are required by TV broadcasting systems in order to remove any undesirable signal.

[0003] The latest television transmitters supplied with solid-state AB Class amplifiers need accurate filtering of high-frequency-transmitted signals. Particularly, in the case of common amplification of sound and vision carriers (SC and VC) strong 3rd Order Intermodulation Products - whose analytical value is 2*f (VC)-f (SC) and 2*f (SC)-f (VC) (IMD) - are generated through beat, and are the most widespread and difficult to eliminate since they are quite close to the transmitted-signal-occupied band. Such undesirable interferences can be removed by means of an output filter featuring specific selectivity degrees concentrated on IMD frequencies. It was not by chance that in the past there was wide use of filters made up with band-stop resonators suitably tuned to the int rference frequencies. More recently, transmitter technology has focused its attention on solid-state AB Class amplifiers, and the output filter requirements have become more demanding.

[0004] At present, the most commonly used filters are band-pass filters featuring at least six resonance cavities and requiring high quality factor resonators to limit insertion losses.

[0005] Alternatively, some filter configurations employ four band-pass resonators with two extra resonators acting as band stop. However, besides being quite bulky, these systems are not completely reliable as regards adjustment and frequency response since they are not based on canonical electrical designs.

[0006] The Circuit theory has recently demonstrated that it is possible to improve classical analytical responses (Chebyshev) by means of generalized schemes allowing extra frequency attenuation poles in the response (R. Levy, "Filters with Single Transmission Zeroes at Real or Imaginary Frequencies", IEEE Transactions on Microwave Theory and Techniques, vol. MTT-24, pp. 172-181, April 1976). A practical result of the above-mentioned theory is present-day high-selectivity filters such as those used in mobile telephony stations. An example of this design technique can be found in: G. Macchiarella, "An Original Approach to the Design of Band-pass Cavity Filters with Multiple Couplings", IEEE Transactions on Microwav Theory and Techniques, vol. MTT-45, pp. 179-187, April 1976.

[0007] The EP 1 045 470 A2 Patent describes a generalized filter according to classical configurations, the specific object of the invention being its peculiar capacitive coupling which can be adjusted between r sonators 2 and 5.

[0008] In any case, as the state of the art demonstrates, at least six coupled resonators are presently needed to conveniently filter a television channel.

[0009] This invention consists of a filter made up of four resonators only, and featuring all the requirements for perfect filtering of a television channel. The main advantages of this invention are a reduction in loss with a given resonator quality factor, a greater mechanical and thermal stability, and a decrease in the size, weight and cost of the device.

[0010] To do this, is required the realization of a generalized coupling filter featuring perfectly symmetrical frequency response and allowing for the correct placing of the attenuation poles at the desirable frequencies. This makes it possible to exploit the typical response of such a filter not only as regards the increase in the transition slope but also in the very high rejection rate of the two attenuation poles in correspondence with the frequencies of the main interferences due to the above mentioned 3rd Order IMD.

[0011] The filter which is the subject of the invention requires high accuracy and symmetry in the frequency response, and cannot be built by means of present-day techniques.

[0012] The solution to the problem has been found in an innovative configuration of the multiple couplings, which virtually eliminates all parasitic couplings causing distortion in the frequency response.

[0013] The following detailed description is aimed at explaining the functioning of this innovative filter, which is here presented in the preferred, but not necessarily definitive, configuration.

See the following Annexes:

Figure 1: Transparent view - Plan
Figure 2: Transparent view - Side
Figure 3: Transparent view - Back
Figure 4: Measured plot of a typical frequency response

[0014] Of course, the synthesis of this device is based upon the latest microwave filter theories, which are not mentioned in this paper. In addition, the component size has been determined by making wide use of the best linear and electromagnetic simulation programs currently available on the market.

[0015] With reference to the Figures, the filter is made up of four cylindrical brass resonators (1) placed in the corresponding square cavities (2). Each resonator features a fixed part (3) and a mobile part (4). The mobile part (4) is driven by means of a small steel rod (5) controlled by a mechanical adjustment devic made up of a control clamp (6) placed on steel spacing bars (7).
The resonators are cascade-coupled by means of adjustable magn tic loops (8) plac d betw en th cavities. The main electrical section of th filter is uniquely designed in that it has a sign reversal in the mutual coupling of th two middle resonators.

[0016] The opposite sign coupling between the second and the third resonators has been achieved follow-

ing an innovative technique by means of a capacitive bridge (9) supported by TEFLON insulators (10). This coupling has been carefully dimensioned by means of 3D Electromagnetic simulation in order to give coupling coefficients almost constant at all tuning frequencies. Fine adjustment is made possible though a concomitant magnetic coupling (11), which, as is known, operates with an opposite sign, thus reducing the effect of the main electrical coupling until the desirable net effect has been achieved.

[0017] Consequently, if compared to the usual configurations, the generalized coupling between the first and the fourth resonators is carried out in a dual way by means of the adjustable magnetic loop (12).

[0018] The end resonators are electrically coupled to the connectors (13) by a highly efficient technique which has been carefully worked out and which employs adjustable probes (14) through connector rotation and locking.

The shape of all the parts used for adjustment has been optimized by means of precise calculations and electromagnetic simulations so as to make coupling adjustment as easy as possible, with minimum variations within the design band.

[0019] Filter thermal stability is ensured by the use of special materials such as INVAR steel, as well as by accurate calculations and simulations aimed at finding out the optimum shapes of the resonance structures.

[0020] The whole device is held inside a screened case made in sheet-brass.

[0021] All internal parts of the filter are silver-plated in order to improve its high-frequency characteristics.

[0022] The filter which is the subject of the invention is particularly innovative as to adjustment simplicity and response quality, thanks to the unique coupling configuration. The electrical design of the invention permits precise adjustment with the generalized response attenuation poles placed at the frequencies of the main interferences, corresponding, in the case of analogue transmissions, to the frequencies of 3rd Order IMD. In addition, global selectivity allowing for a reduction in desirable emissions is ensured, according to all current regulations worldwide.

[0023] The above-mentioned characteristics are shown in Fig. 4, which shows the frequency response of a typical channel adjustment.

[0024] Although the filter has been specifically described with reference to a preferred configuration, it can, obviously, undergo any change or variation within the parameters of the inv ntion.

[0025] A second-choice configuration will consist of a six-resonance cavity filter, featuring a cascade-coupled cavity in front of each input coupling.

[0026] In a third-choice configuration, the filt r will f atur eight resonance caviti s characterized by two cascade-coupled cavities in front of each input coupling.

[0027] These two configurations still maintain the main advantages of the first, such as perfect response symmetry and easy adjustment, and at the same time are characterized by greater general selectivity, which makes them particularly suitable for future DVB broadcasting transmissions, which are currently under development. These transmissions employing digital coding require extremely selective broadcasting filters (Ref. ETSI EN 300 744 V1.4.1)

Claims

1. UHF TV broadcasting band pass filter made up of four cylindrical square-cavity resonators with generalized couplings, **characterized by** a sign reversal between the middle resonators, the filter end sections being coupled to the input and output connectors by means of adjustable probes with mechanical rotation of the connectors.

2. Band pass filter as described in Par. 1 above, **characterized by** the fact that the sign reversal in the coupling between the middle resonators is carried out by means of capacitive coupling between the second and the third resonators, whose adjustment is obtained by a corresponding adjustable magnetic coupling.

3. Filter as described in Par. 1 and 2 above, **characterized by** generalized coupling between the first and the fourth resonators, provided with adjustable magnetic coupling.

4. Filter as described in the above Paragraphs, **characterized by** the fact that the accuracy of the obtainable response permits calibration perfectly suitable for the filtering requirements of analogue TV broadcasting, by placing the attenuation poles at the frequencies of the main 3rd Order IMD.

5. Filter as described in the above Paragraphs, **characterized by** the fact that filtering requirements are fulfilled with a four-resonator minimum order.

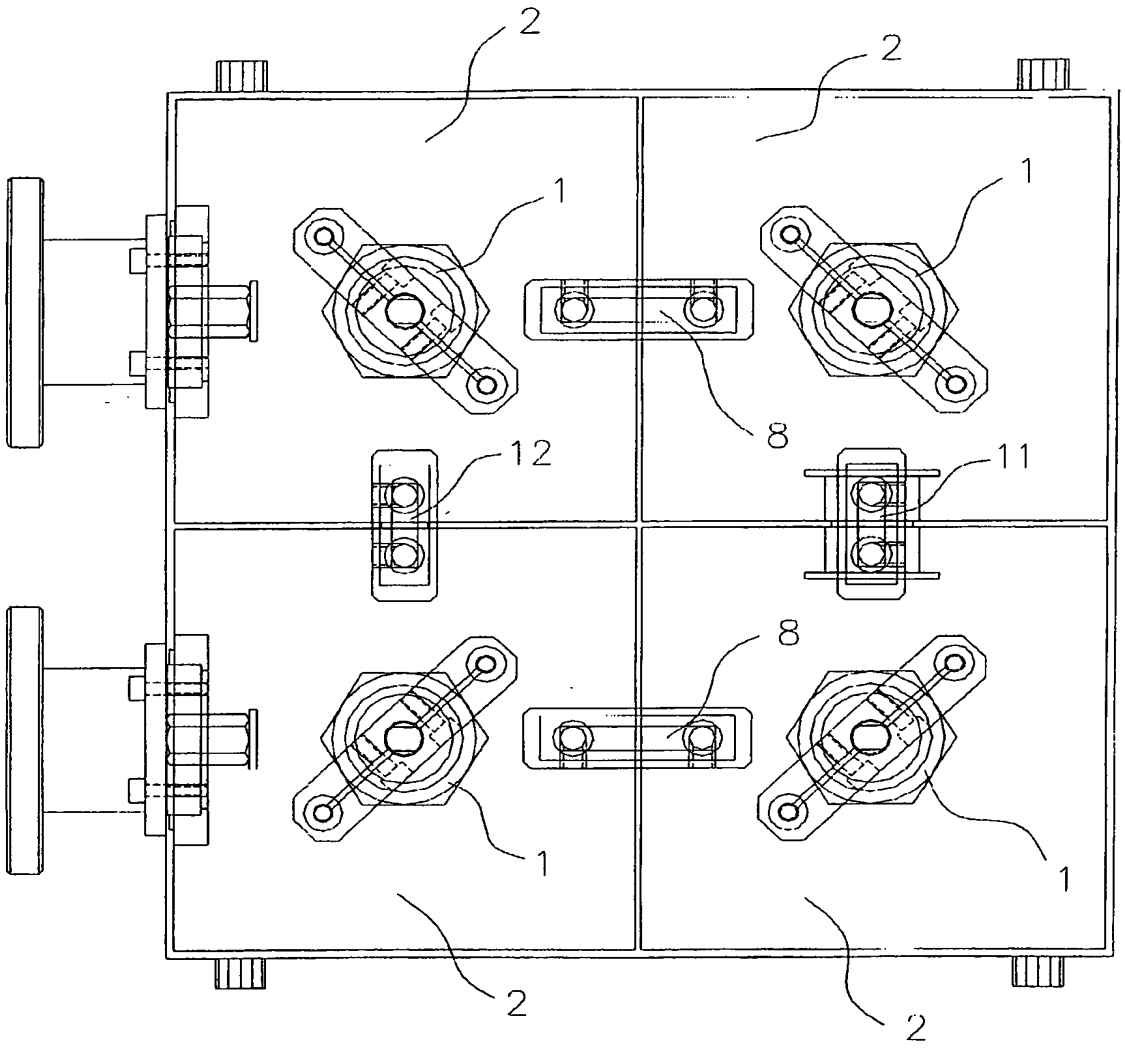

Fig. 1

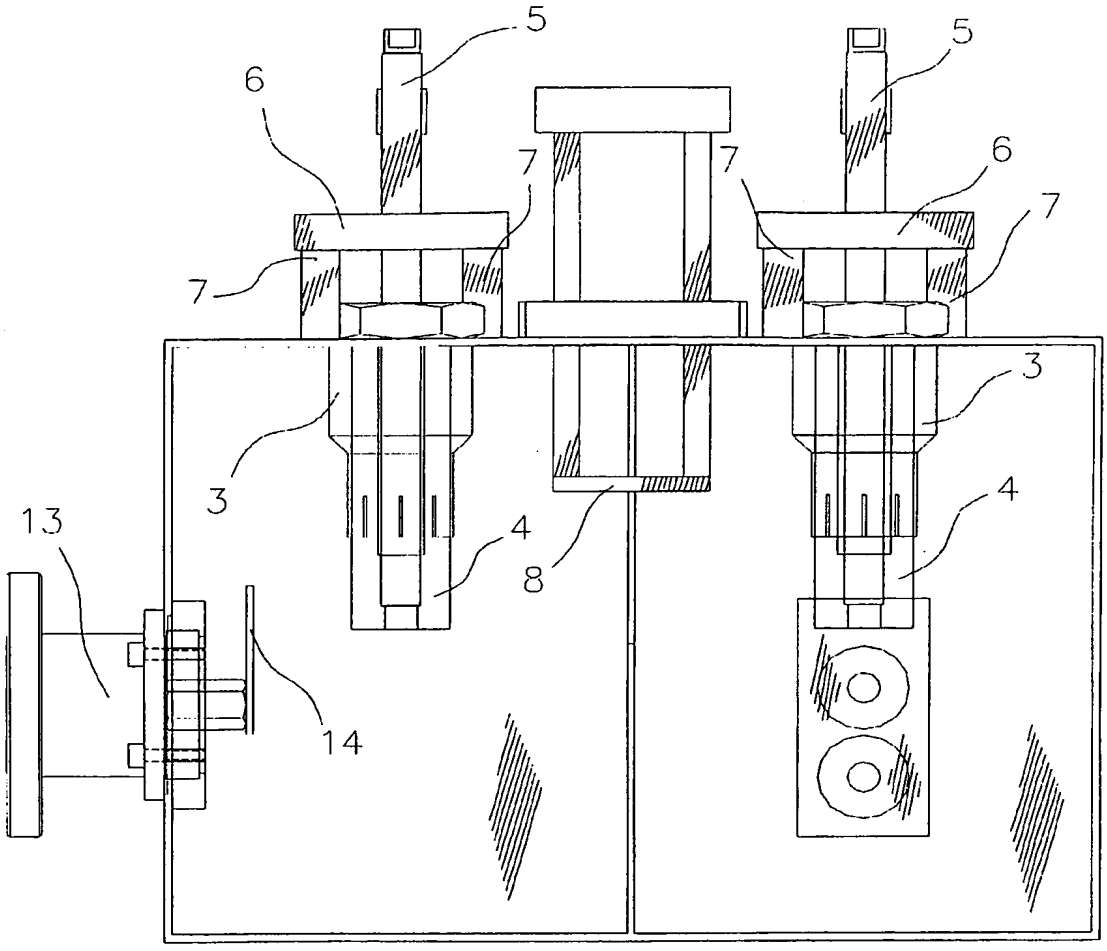

Fig. 2

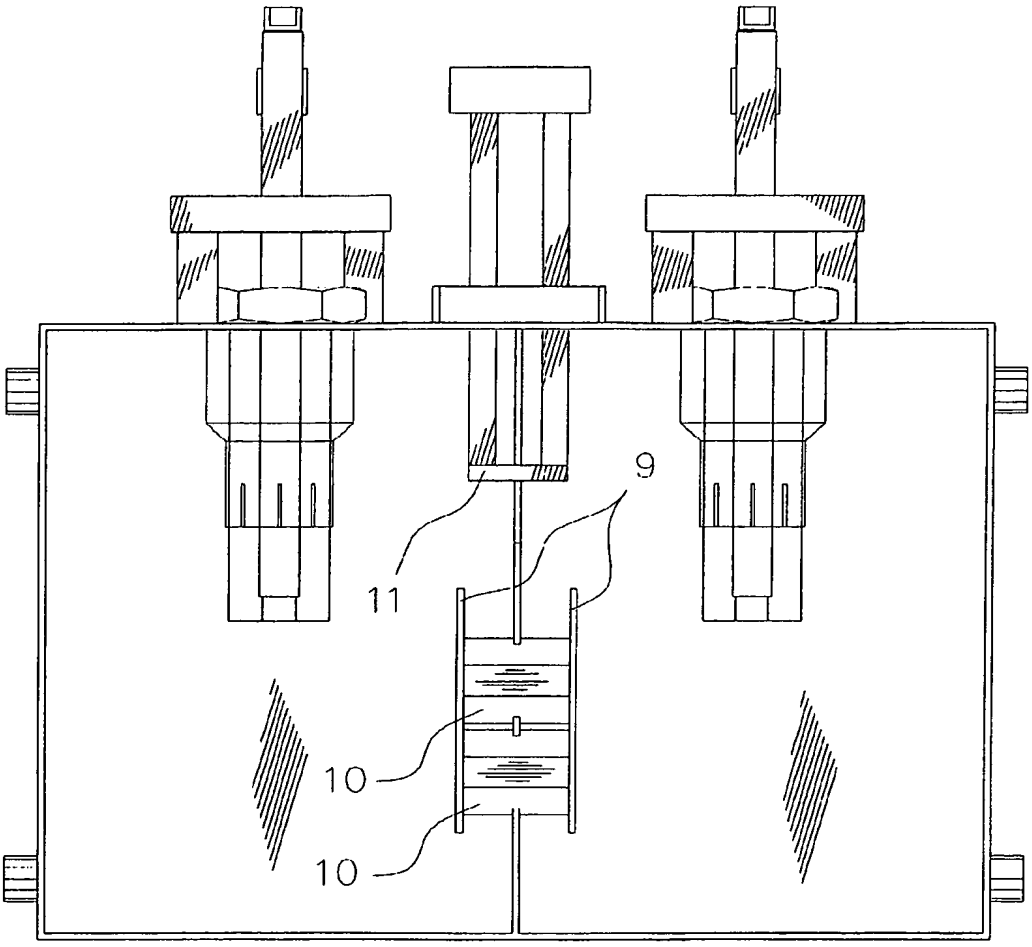

Fig. 3

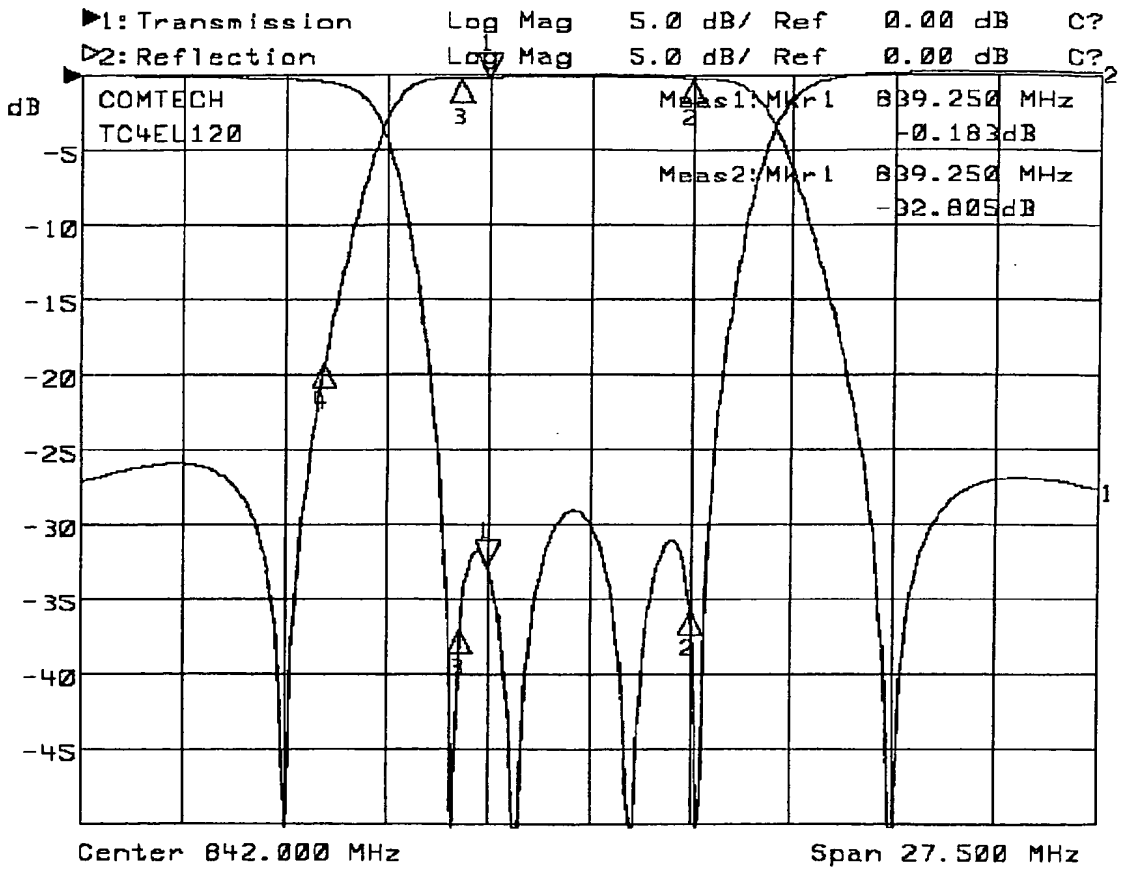
1: Transmission Log Mag 5.0 dB/ Ref 0.00 dB C?
2: Reflection Log Mag 5.0 dB/ Ref 0.00 dB C?
COMTECH
TC4EL120
Meas1:Mkr1 839.250 MHz
-0.183dB
Meas2:Mkr1 839.250 MHz
-32.805dB
dB
-5
-10
-15
-20
-25
-30
-35
-40
-45
Center 842.000 MHz
Span 27.500 MHz

Fig. 4

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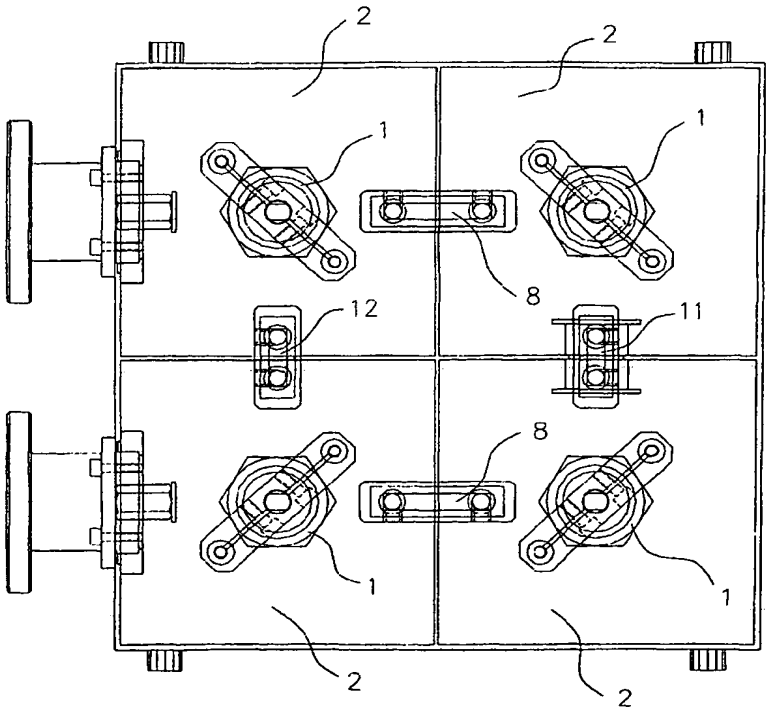

Fig. 1

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 42 5250

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	EP 0 813 266 A (BOSCH GMBH ROBERT) 17 December 1997 (1997-12-17) * column 2, line 42 - column 3, line 46; figures 1-3 *	1,3-5	H01P1/205
Y	US 5 625 330 A (WILSON WILLIAM E ET AL) 29 April 1997 (1997-04-29) * column 1, line 15-19; figure 1 *	1,3-5	
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A	US 6 094 113 A (BARTLEY LUCY ET AL) 25 July 2000 (2000-07-25) * the whole document *	1-3	
A	PICHLER K ET AL: "VIERKREIS-UHF-BANDFILTER YH AF 1010" BAUTEILE REPORT SIEMENS, BAUTEILE REPORT. MUNCHEN, DE, vol. 6, no. 6, 1 December 1968 (1968-12-01), pages 200-201, XP002042875 * page 200, right-hand column, paragraph 4; figure 1 *	1-5	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	3 July 2003	Kaleve, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 02 42 5250

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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03-07-2003

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